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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Stent Fabrication Method

(72) Richter, Jacob - Israel ;  
Yaron, Ira - Israel ;

(71) Medinol Ltd. - Israel ;

(30) (US) 08/330,625 1994/10/27

(57) 5 Claims

Notice: This application is as filed and may therefore contain an incomplete specification.



# ABSTRACT

A stent and a method for fabricating the stent are disclosed. The stent has an originally flat pattern and connection points where the sides of the flat pattern are joined. The method includes the steps of a) cutting a stent pattern into a flat piece of metal thereby to produce a metal pattern, b) deforming the metal pattern so as to cause two opposing sides to meet, and c) joining the two opposing sides at least at one point.

**STENT FABRICATION METHOD**  
Jacob Richter and Ira Yaron

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**FIELD OF THE INVENTION**

The present invention relates generally to methods of fabricating stents.

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**BACKGROUND OF THE INVENTION**

Stents are known in the art. They are typically formed of a cylindrical metal mesh which can expand when pressure is internally applied. Alternatively, they can be formed of wire wrapped into a cylindrical shape.

As described in U.S. 4,776,337 to Palmaz, the cylindrical metal mesh shape is produced by laser cutting a thin walled metal tube. The laser cuts away all but the lines and curves of the mesh.

The method of U.S. '337 is applicable for relatively large mesh shapes and for meshes whose lines are relatively wide. However, for more delicate and/or intricate shapes, the spot size of the laser is too large.

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## SUMMARY OF THE PRESENT INVENTION

It is, therefore, an object of the present invention to provide a stent fabrication method which can produce stents with  
5 relatively intricate and/or delicate designs.

The method involves first creating a flat version of the desired stent pattern from a piece of thin sheet metal. The flat pattern can be produced through any suitable technique, such as etching the design into the sheet metal, or by cutting with a very  
10 fine laser, should one become commercially available or by any other technique.

Once the sheet metal has been cut, it is deformed so as to cause its edges to meet. To create a cylindrical stent from a flat, roughly rectangular metal pattern, the flat metal is rolled  
15 until the edges meet. The locations where edges meet are joined together, such as by spot welding. Afterwards, the stent is polished, either mechanically or electrochemically.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a flow chart illustration of the stent fabrication method of the present invention;

Figs. 2A, 2B and 2C are illustrations of three alternative stent patterns to be etched, in accordance with the method of Fig. 1, into a flat sheet of metal;

Fig. 3 is an isometric illustration of a stent being deformed, useful in understanding the method of Fig. 1;

Fig. 4 is an isometric illustration of a stent formed from the method of Fig. 1;

Figs. 5A and 5B are side and top view illustrations, respectively, of one connection location of the stent of Fig. 4; and

Fig. 6 is a side view illustration of one connection location of the stent of Fig. 4 which is connected in a nail-like manner.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is now made to Fig. 1, which illustrates the stent fabrication method of the present invention and to Figs. 2A, 2B, 2C, 3 and 4 which are useful in understanding the method of Fig. 1.

In the stent fabrication method of the present invention, a stent designer first prepares a drawing of the desired stent pattern in a flat format (step 10).

10 Figs. 2A, 2B and 2C illustrate three exemplary stent pattern designs. The pattern of Fig. 2A has two types of sections 20 and 22. Each section 20 has two opposing periodic patterns and each section 22 has a plurality of connecting lines 24. The pattern of Fig. 2A can be formed of any size; a preferable size is  
15 to have each section 20 be between 1 and 6mm wide and each section 22 have connecting lines 24 of 1 - 6mm long. At such sizes, the pattern of Fig. 2A cannot be cut using a laser cutting system.

The pattern of Fig. 2B is similar to that of Fig. 2A in that it also has sections 20 of opposing periodic patterns. The  
20 pattern of Fig. 2B also has connecting sections, labeled 30, which have a Z shape.

The pattern of Fig. 2C has no connecting sections. Instead, it has a series of alternating patterns, labeled 32 and 34.

25 The patterns of Figs. 2A, 2B and 2C optionally also have a plurality of small protrusions 38 which are useful in forming the stent, as described hereinbelow.

Returning to Fig. 1, in step 12, the stent pattern is cut into a flat piece of metal ("sheet metal"). The metal can be any  
30 type of biocompatible material, such as stainless steel, or a material which is plated with a biocompatible material. The cutting operation can be implemented in any of a number of ways, such as by etching, or by cutting with a fine cutting tool, or by cutting with a very fine laser, should one become commercially  
35 available.

If step 12 is implemented with etching, then, the process is designed to cut through the sheet metal. This process is known; however, for the purposes of completeness, it will be briefly described hereinbelow.

5           The drawing of the pattern is reduced and printed onto a transparent film. Since it is desired to cut completely through the metal, the drawing is printed onto two films which are joined together in a few places along their edges. The sheet metal is covered, on both sides, with a layer of photoresist and placed  
10 between the two transparent, printed films. The structure is illuminated on both sides which causes the portions of the photoresist which receive the light (which are all the empty spaces in the pattern, such as spaces 26 of Fig. 2A) to change properties.

          The sheet metal is placed into acid which eats away those  
15 portions of the photoresist which changed properties. The sheet metal is then placed into an etching solution which etches away all material on which there is no photoresist. The resultant sheet metal is placed into a photoresist-removing solution which removes the photoresist, leaving the metal having the desired stent  
20 pattern.

          In step 14, the metal pattern is deformed so as to cause its long sides (labeled 23 in Figs. 2A, 2B and 2C) to meet each other. Fig. 3 illustrates the deformation process. For cylindrical stents, the deformation process is a rolling process,  
25 as shown.

          If the protrusions 38 have been produced, after deformation of the metal pattern, the protrusions 38 protrude over the edge 28 to which they are not attached. This is illustrated in Fig. 5A.

30           In step 16, the edges 28 are joined together by any suitable process, such as spot welding. If the protrusions 38 were made, the protrusions 38 are joined to the opposite edge 23, either by welding, adhesive or, as illustrated in Fig. 6, with a nail-like element 40. Fig. 5B illustrates the connection of the protrusion  
35 33 to the opposite edge 23. Since protrusion 38 is typically

designed to extend the width of one loop 39, the pattern is approximately preserved. This is seen in Fig. 5B.

Alternatively, the edges 28 can be brought together and joined in the appropriate places.

5 Fig. 4 illustrates a stent 31 formed by the process of steps 10 - 16 for the pattern of Fig. 2A. It is noted that such a stent has connection points 32 formed by the joining of the points 30.

10 Finally, the stent 31 is polished to remove any excess material not properly removed by the cutting process (step 12). The polishing can be performed mechanically, by rubbing a polishing stick having diamond dust on its outside inside the stent 31. Alternatively, an electropolishing unit can be utilized.

15 It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow:



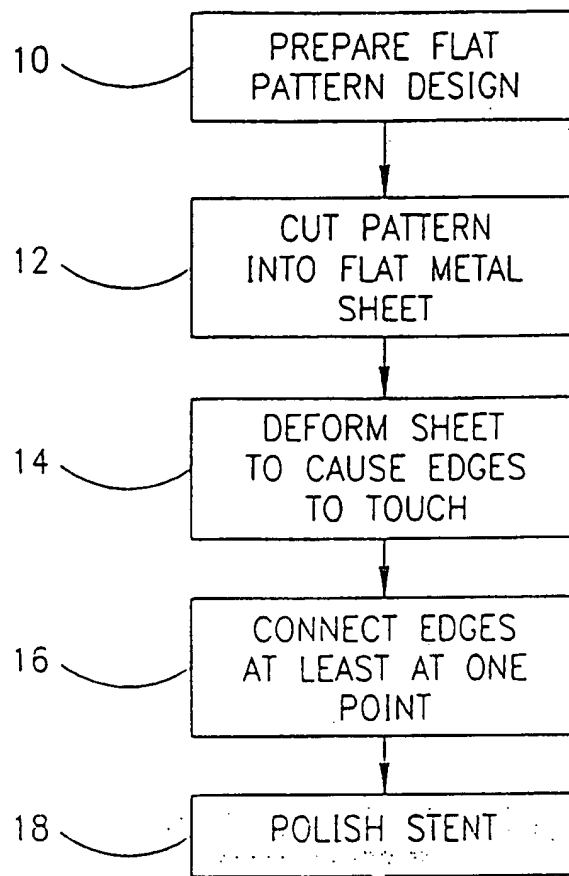


FIG. 1

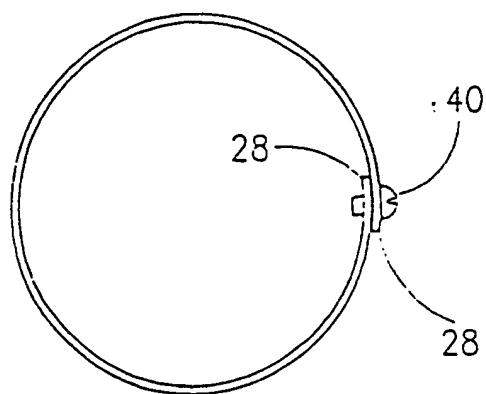


FIG. 6

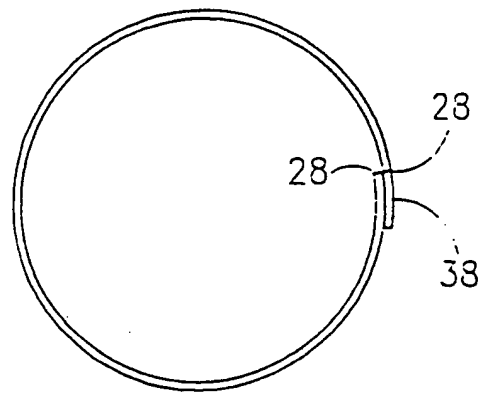


FIG. 5A

FIG. 2B

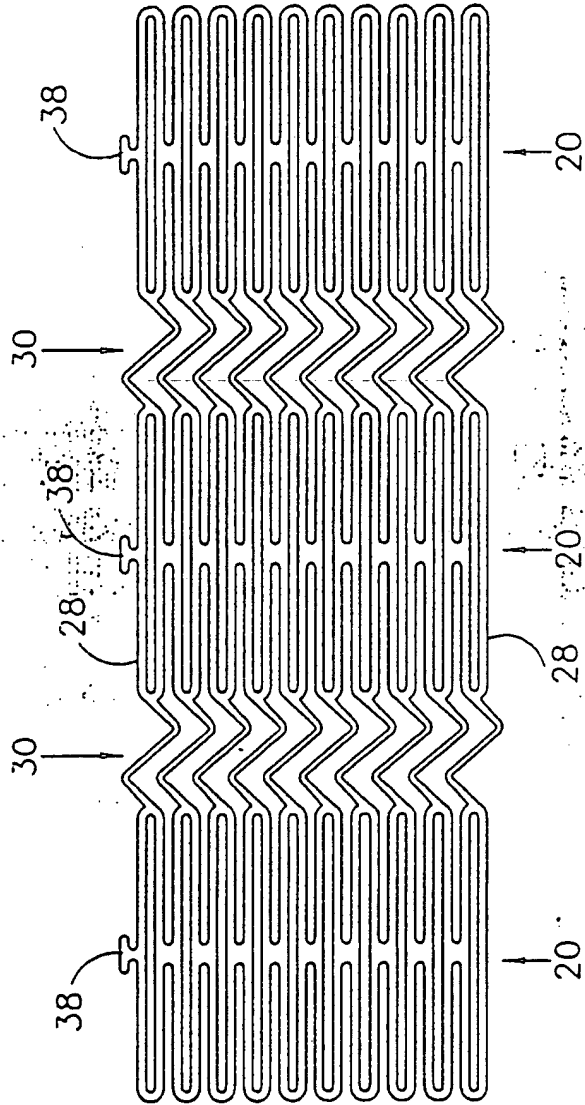
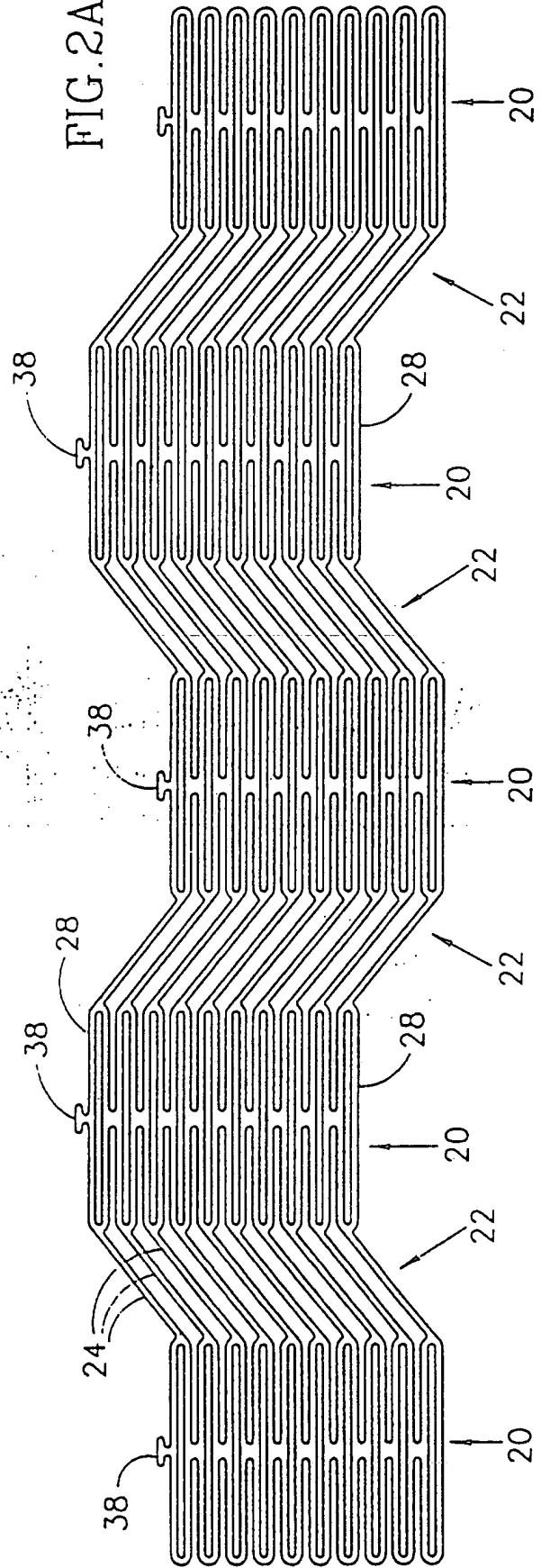


FIG. 2A



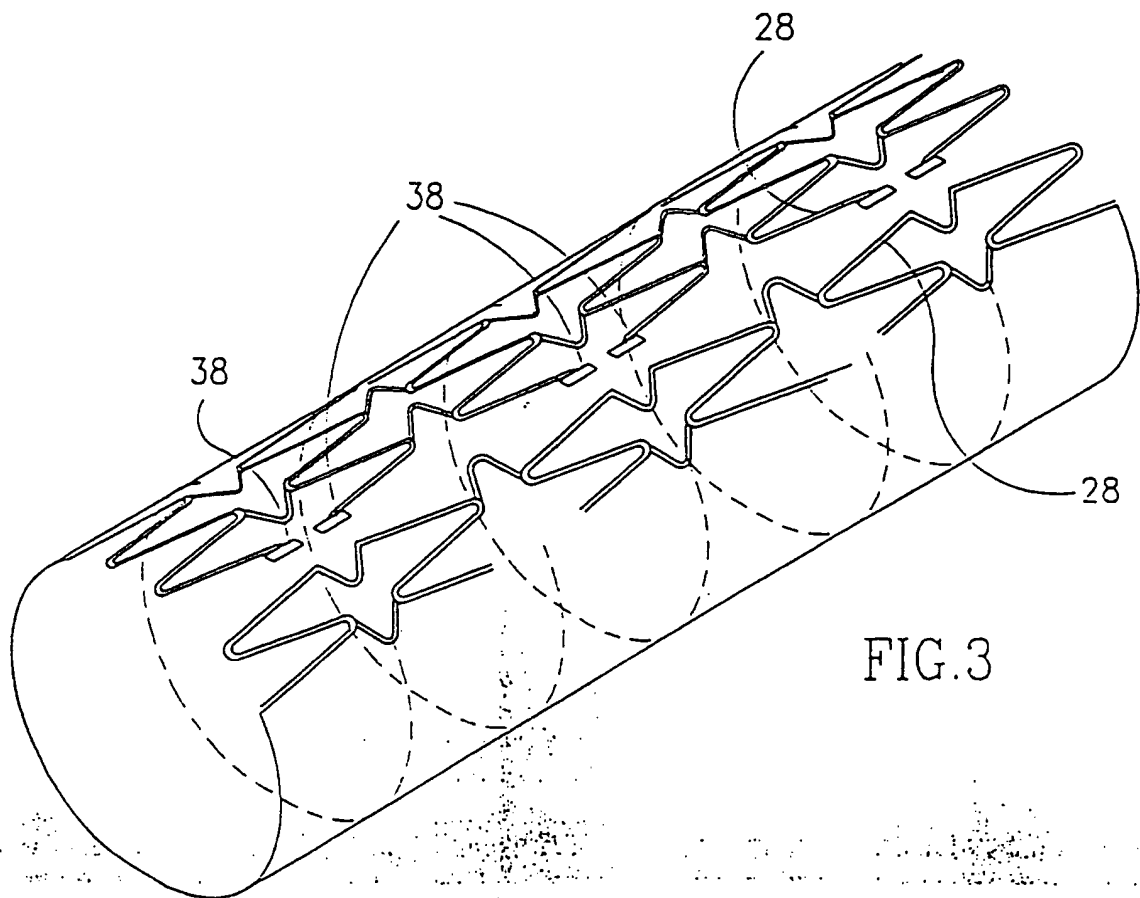


FIG. 3

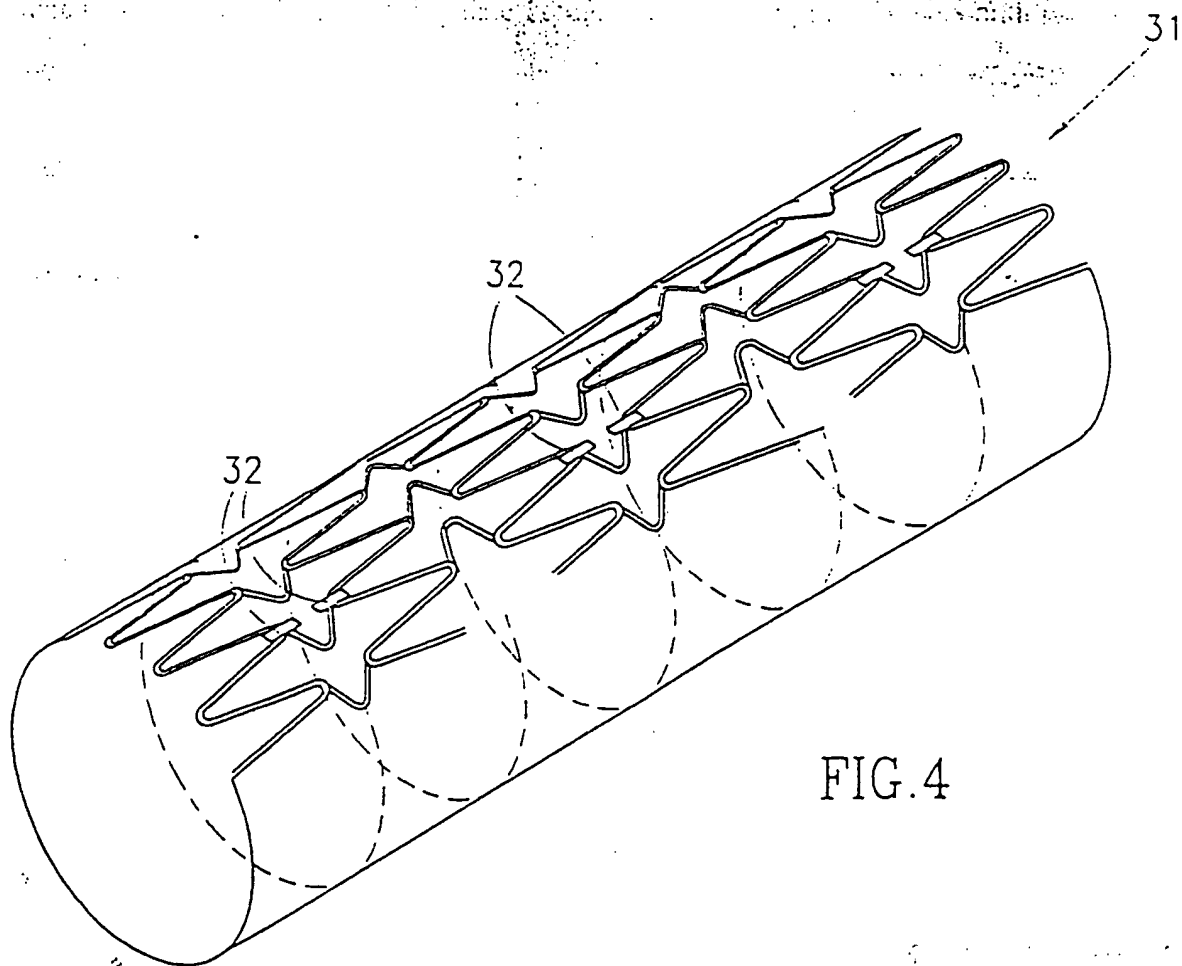


FIG. 4

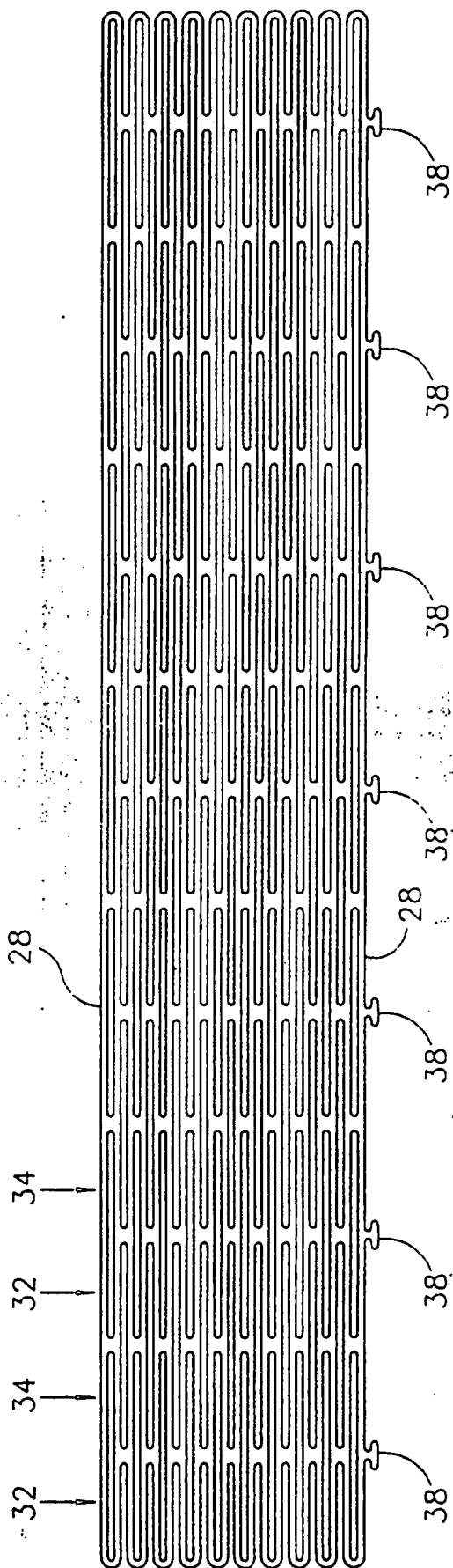


FIG. 2C

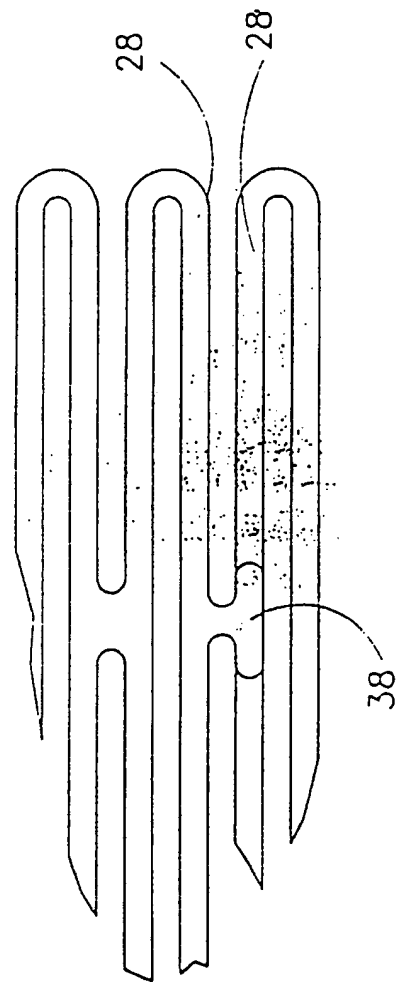
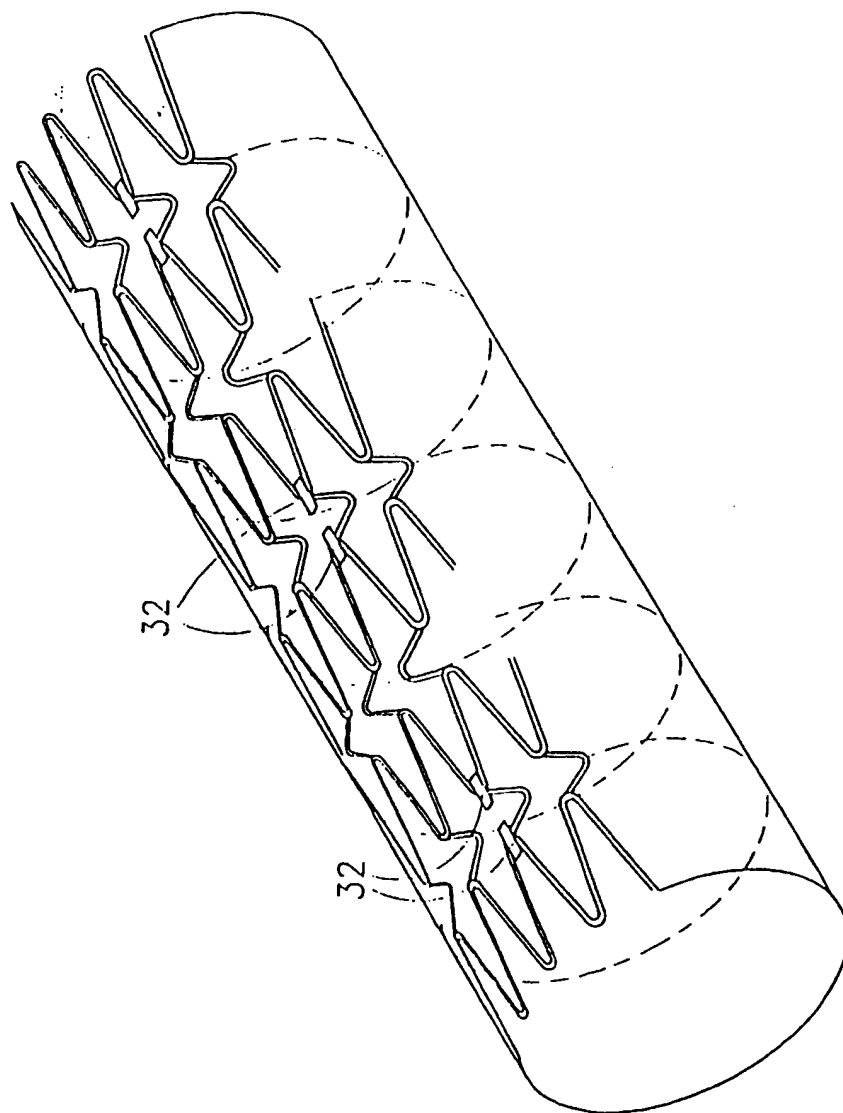


FIG. 5B



## CLAIMS

1. A stent fabrication method comprising the steps of:  
cutting a stent pattern into a flat piece of metal  
5 thereby to produce a metal pattern;  
deforming said metal pattern so as to cause two opposing  
sides to meet; and  
joining said two opposing sides at least at one point  
thereby to produce a stent having said pattern.  
10
2. A method according to claim 1 and also including the step  
of polishing said stent.
3. A method according to claim 1 and wherein said step of  
15 cutting comprises the step of etching said metal to produce said  
pattern.
4. A stent having an originally flat, stent pattern and  
connection points where sides of said flat pattern are joined.  
20
5. A stent according to claim 4 and wherein said originally  
flat, pattern is formed from a piece of flat metal.

Smart & Diggar  
Ottawa, Canada  
Patent Agents